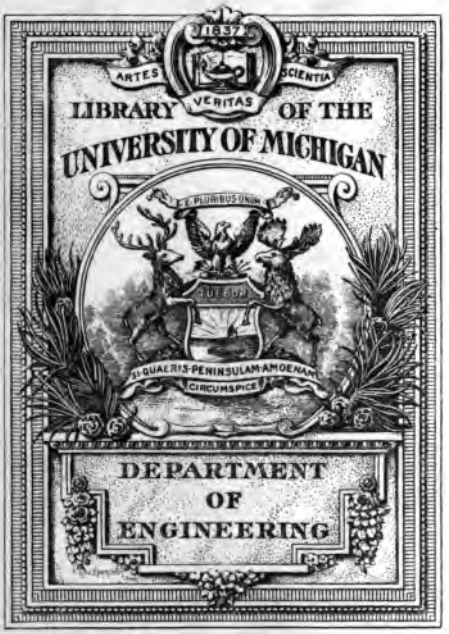
STANDARD FORMS OF FIELD NOTES FOR CIVIL ENGINEERS

CHARLES C. ANTHONY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STANDARD FORMS

OF

FIELD NOTES

FOR

CIVIL ENGINEERS

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OF

FIELD NOTES

FOR

CIVIL ENGINEERS

BY

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PREFACE

The object of this book is to present forms for note-taking, and such necessary instructions in the use of them, that an engineer can take a complete set of notes and record the results of a survey in neat and workman-like manner.

In all the books dealing with Surveying and Railroad Location very little space has been given to the art of recording notes. An engineer who has worked long in the field will gradually develop a system of note-keeping which he will follow in a general way time after time; yet he will sometimes vary from his form in a few minor instances just enough to confuse a draftsman. As for the younger members of the profession, it is often hard for them to record the results of their surveys in such a manner that they can translate the notes themselves, unless they are plotted while the survey is still fresh in their minds.

It is a very common thing to see an engineer called into the office to explain his notes to the draftsman; or a party returned to the field to get information which should have been taken in the original survey.

An engineering party can be placed in the field and maintained only at a very large expense; and speed and accuracy is demanded by every employer. If the instrument man cannot record his notes properly the speed of the party is reduced and the accuracy is

questionable. There is always doubt regarding notes which are not self-explanatory.

The note-book serves as a very good criterion for the Chief Engineer to judge of the efficiency of the party in the field, and many fieldmen have failed to make good engineers, even though they could make accurate and speedy surveys, because they could not present the data obtained in a plain and concise manner.

No attempt has been made to have the following sketches appear as finished drawings as this would, in a measure, defeat the object of the book.

It is with the hope that note-taking may be simplified and standardized that this book is published.

CONTENTS

LIST OF PLATES

GENERAL INSTRUCTIONS

All notes should be taken with a 4H pencil. A softer pencil will blur and rub out, while a harder one will make very dim lines and, if pressed too hard, will tear the paper.

All notes should be indexed, giving name of the survey, where taken and for what purpose; the same name being used for the notes that are placed on the map.

Do not congest notes. As a rule sketches are made so small that, when the dimensions and dimension lines are placed on the page, the notes are so congested that they can only be read after a great sacrifice of time and patience. It is the apparently unimportant things that give the sketches a finished and neat appearance.

Show all sketches on the right-hand page. They should be drawn approximately to scale. This should be accomplished by eye only, as time should not be taken in the field to use a scale. At least a separate line should be used for each plus. This will distort the sketch somewhat, except the lateral distances; but it is more important that the sketch be easily translated than that it be to scale.

All railway track surveys should be tied to the mile posts. All other surveys should be tied to some section corner of other permanent monument. Locate land lines by angles and distances to corners.

Record notes directly in the field-book; do not take notes on separate sheets of paper and then transfer to the field-book at a later date, as is the practice with some engineers. In fact, some railroads are so set against this practice that it is considered sufficient reason for dismissal from the service.

STANDARD FORMS OF FIELD NOTES

STATION LAYOUT SURVEYS

It is customary in railroad work to have on file a survey of each station layout on the road. This survey should show all tracks, station buildings, frogs, switches, right-of-way lines, buildings along right of way, alinement, and all physical features such as bridges, waterways, rock bluffs, etc., that would affect the changing or remodeling of the station layout.

To get a complete set of notes, and, at the same time, take the data in such a way that it can be easily recorded, the survey should be made as follows:

Take some mile post at one end of the limit to be surveyed and call it Station 0.0. Start chaining from this point, marking every hundred-ft. station on the base of rail; also all plusses to point of frog, point of switch, building line, etc. After the distances have been marked on the rail the instrument man should walk along the track and record each station and plus on the left-hand page of the field-book, in the same order that they come on the rail. After the plusses are properly recorded the sketch should be made, placing each object on the right-hand page opposite the correct plus on the left-hand page. At the same time take all track centers and lateral distances and record them on the sketch on the right-hand page.

All curves should be rerun and enough information taken to determine the degree and location of the Point of Curve and the Point of Tangent. To do this, take deflections around the curve, chaining all chords and taking the plus at the end of each chord. Locate intermediate points on the track by offsets from the chords every 50 ft., measured along the chord.

By calling the beginning of the first chord measured, Station 0.0, a new system of stations can be used along the chord for offsets and angle points, recording the same in Column 6 of the notes. Thus the assumed stationing will not conflict with the true stations on the curve, to be found later.

The line in the center of the right-hand page should be used as the center of main track unless otherwise noted.

All lateral distances should be measured at right angles to the center line unless the angle is turned with a transit or otherwise shown.

When possible the offset measurements should be shown as continuous distances from the center line of track. Topography and track centers on curves must be measured from the center line of the main track, not from chords. The chords should be used only in locating the center line of the main track on curves as previously explained. Important topography and spur tracks distant or inaccessible from the main line must be located from base lines established for that purpose. The base lines thus used should be tied at both ends to the main traverse line and the closing angle determined.

Base lines should be figured and checked in the

field before the party leaves the locality. On very extensive surveys the notes should be plotted in the field. A desk or table can be secured in the depot or freight office that would do for this purpose. (For method of recording see Plates A, B, C and D.)

In case the survey is to be used in connection with an investigation for increased station facilities, a new section house, proposed yard developments, etc., additional information should be obtained and recorded as follows:

INFORMATION TO BE OBTAINED IN CONNECTION WITH PROPOSED YARD DEVELOPMENTS

1. Number of engines coaled and sent out each day.
2. Maximum numbers of engines to be cleaned in any one hour.
3. Number of cars of cinders made each day.
4. Number of engines coaled each day.
5. Amount of coal used in tons for twelve months.
6. Number of engines taking water each day.
7. Amount of water used each month for one year.
8. What is present water supply and cost of same?
   (a) Analysis of water used.
9. Number of engines on each "ready" track, after cleaning and coaling, ready for work.
10. Number of "ready" tracks for engines.
11. Maximum number of engines to be housed at any one time.
12. Maximum number of engines waiting for the cinder pit.
13. Average number of engines to be housed.
14. Number of driver drop pits.

15. Number of truck drop pits.
16. Size of store house.
17. Size of engine shop.
18. Size of each office and number of men working in same.
19. Average number of shop cars repaired each day.
20. Maximum number of shop cars in yard at any one time.
21. Size of shop car buildings.
22. Space for shop car material.
23. Maximum number of cabooses laid over in each direction.
24. Maximum number of cars sent out in one day from the transfer shed.
25. Number of freight cars arriving in yard each day (each direction).
26. Number of freight cars leaving yard each day (each direction).
27. Maximum number of freight cars in the yard any day in the past twelve months.
28. Maximum and average freight trains arriving in any one day and any one hour in each direction.
29. Maximum and average number of loads and empties in a freight train in each direction.
30. Distance from the yards to each of the adjoining terminals.
31. Grades between the adjoining terminals.
32. Number of passenger trains ending their runs at the yards, also number of cars in each train.
33. Location of electric lights.
34. Location of gas pipes for charging departing trains.

35. Number of yard engines.
36. Price of land around yards.
37. Direction of prevailing wind.
38. Make a complete station layout survey.

INFORMATION TO BE OBTAINED WHERE A CHANGE IN STATION FACILITIES IS INVOLVED

1. In what state?
2. Is the city a state capital?
3. Is the city a county seat?
4. Population of the town or city for the past two censuses, showing rate of increase.
5. What are the principal industries of the town or city?
6. Character of the surrounding country, whether farming, grazing, etc.
7. Prospects of future growth of the town or city.
8. Has the town a water-works and electric light plant? Giving rate per thousand gallons and per kilowatt hour.
9. What distance from the station is the nearest sewer?
10. Condition of station grounds and how they are drained.
11. Competition, if any, and of what it consists.
12. Condition of driveways between station and town or city.
13. Is the public satisfied with the present location of the station?
14. What are the fire ordinances of the city?
15. Is the operator's view obstructed in both directions or either direction?

16. Are telegraph batteries in station, if so, how many?

17. What is distance to nearest water plug?

18. Give number of men on station pay-roll and each occupation.

19. Number of passenger trains stopping at the station daily.

20. Give condition of present station.

21. Is it necessary to provide living quarters for agent at this point?

22. Get the name of President and Secretary of the City Board of Trade or similar organization.

23. Make a complete station layout survey showing size of all buildings and platforms.

Information to be obtained Where Section Houses are Recommended

1. Give station, division and state.

2. Population of town.

3. Present rate of pay of foreman.

4. Monthly rental of houses in town which would be suitable for a foreman.

5. Number of miles of section each way from town.

6. Have foremen on sections each side, houses?

7. Rate of pay for foremen each side.

8. Are there other company foremen with headquarters in this town?

9. Are there other railroads with foremen-headquarters in this town?

10. Kind of labor employed.

11. Is labor boarded by foreman?

12. Should facilities be provided for foreman to board labor?

13. Is labor housed by foreman or company?

14. Maximum and average number of laborers on section in winter and in summer.

15. Number of persons in foreman's family.

16. Nationality of present foreman.

17. Length of service of present foreman.

18. Where does foreman live now?

19. Make a complete station layout survey.

INFORMATION TO BE OBTAINED WHERE A WATER STATION AND RESERVOIR ARE TO BE CONSTRUCTED

1. Make a survey showing size of water shed in acres, also location of watershed with reference to tracks (see Stadia Notes, Plate F).

2. Character of land in watershed.

3. Yearly rain-fall in inches for five years.

(a) Analyses of water in proposed location.

4. Length of dry spell which can be expected.

5. Per cent. of water which will reach the dam.

6. Are there any mines on the watershed that would injure the water?

7. Take enough elevations so that capacity of reservoir can be computed.

8. Figure amount in gallons which will be lost per day through seepage and evaporation.

9. Show on sketch location of dam and spillway.

10. Give sketch of pipe layout.

11. Give elevations at

a. Base of rail at water station.

PLATE A

Station	STATION SURVEY				
+33.4	Cattle Guard				
11+00	Xing Sign				
+96.2	Center 16' Plank Xing				
+72.4	Cattle Guard				
9+00					
8+50					
8+00	Turn Angle to Barn				
7+50					
7+00					
6+50					
6+00	Turn Angle to Barn				
+86.2	Center Xing (C.B.&Q.R.R.)				
5+00					
4+50					
4+00	End of Pile Trestle				
+81.2	Edge of Water				
+50.3	Edge of Water				
+45.0					
+40.0	End Trestle No 360				
3+00					
2+00					
+38.1	Section Line				
1+00					
0+00	M.P. 420				

PLATE A

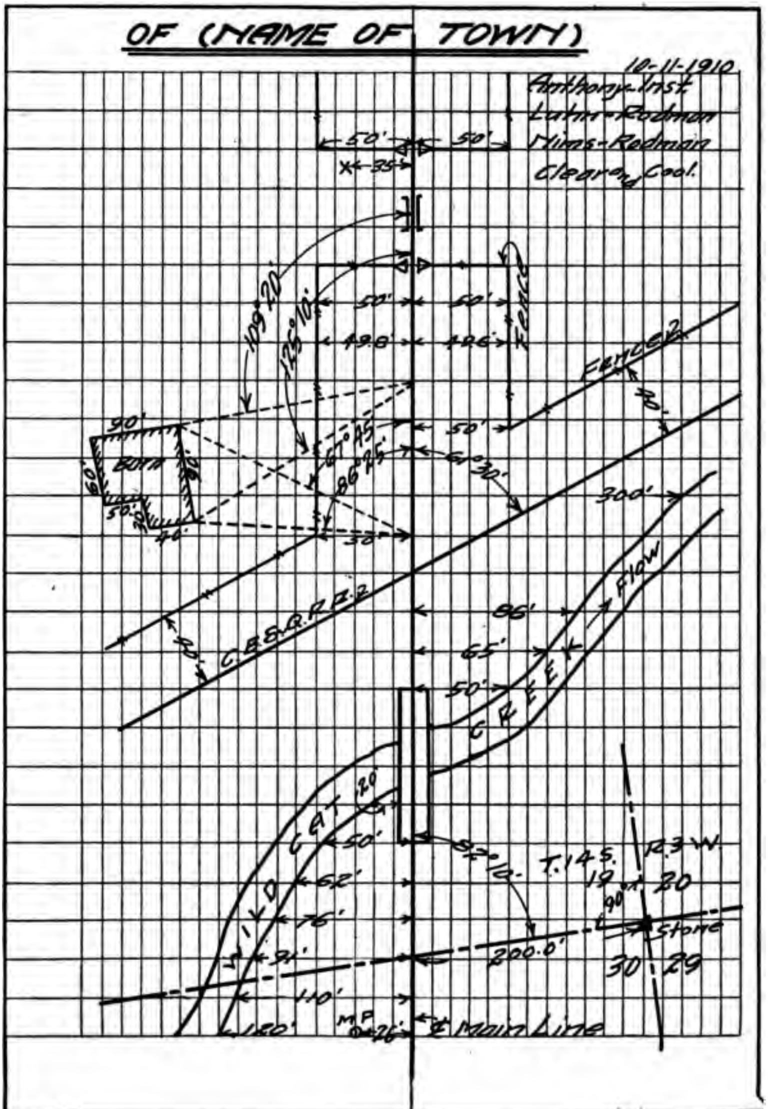
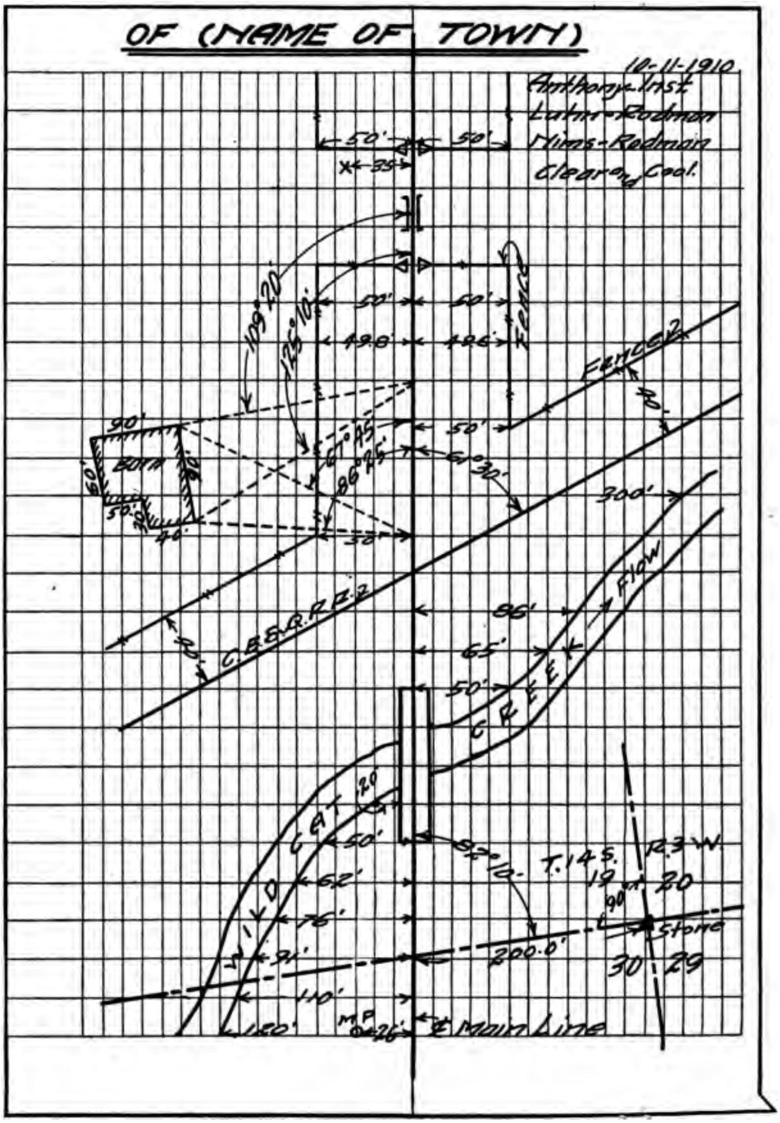

OF (NAME OF TOWN)
10-11-1910
Anthony-Inst.
Luhn-Rodman
Mims-Rodman
Clear and Cool.
FENCE
C.B.&Q.R.R.
FLOW
CREEK
DIVIDE CAT
T.14 S.
R.3 W.
19
20
30
29
Stone
200.0'
M.P. 0+26
℄ Main Line

PLATE A

Station	STATION SURVEY
+33.4	Cattle Guard
11+00	Xing Sign
+96.2	Center 16' Plank Xing
+72.4	Cattle Guard
9+00	
8+50	
8+00	Turn Angle to Barn
7+50	
7+00	
6+50	
6+00	Turn Angle to Barn
+86.2	Center Xing (C.B.&Q.R.R.)
5+00	
4+50	
4+00	End of Pile Trestle
+81.2	Edge of Water
+50.3	Edge of Water
+45.0	
+4.00	End Trestle N.S. 360
3+00	
2+00	
+32.1	Section Line
1+00	
0+00	M.P. 420.

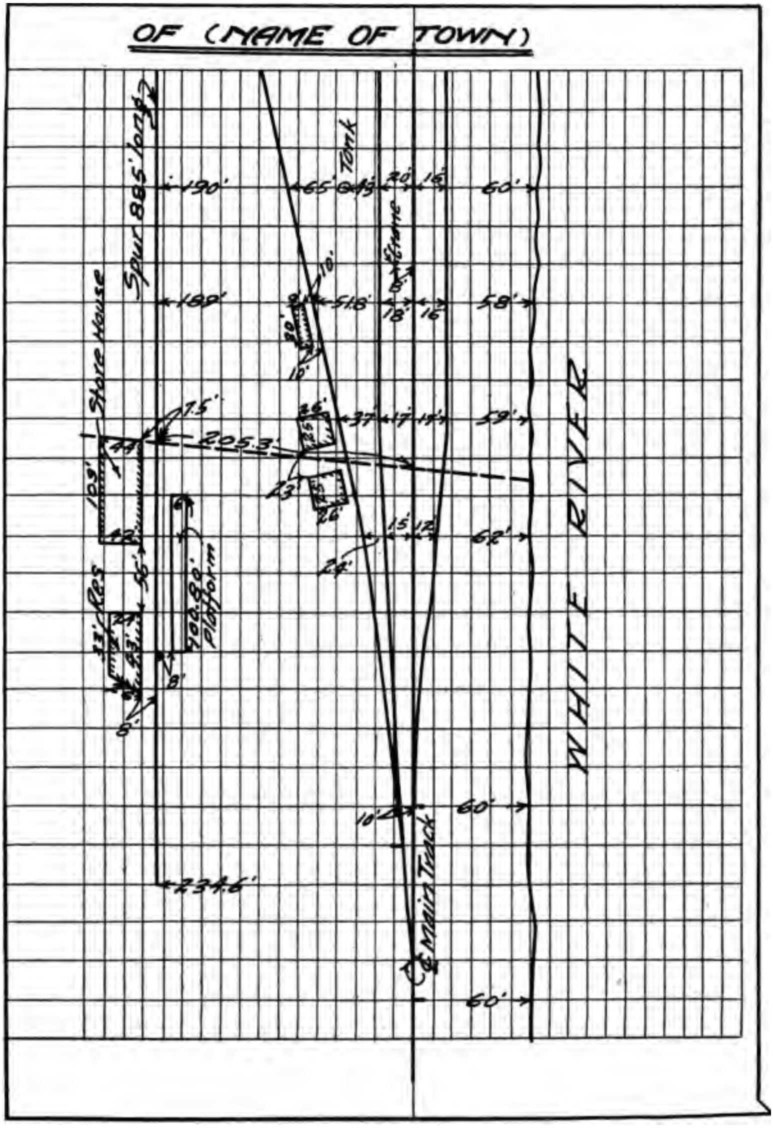
PLATE A


OF (NAME OF TOWN)
10-11-1910
Anthony-Inst.
Lutm-Rodman
Mims-Rodman
Clear'g Cool.
Fence
Fence
Barn
C.E.E.R.R.
Creek
Flow
Cat
Side
T.14 S.
R.3 W.
19
20
30
29
Stone
200.0'
M.P.
Main Line

STATION SURVEY

Station	
201	Center Water Tank
+40	" " Crane
200	
+62.8	East End Car Body
199	End of 25'x26' Shed
+74.5	East Bldg Line Street
+50.9	End Timber Platform
198	
+58.8	P.F. on Ladder Track
+45.7	P.F. Track Right
197	
+85.0	P.S. Track Right
+81.6	P.S. on Ladder Track
+80.3	End Spur Left
+61.8	
196+01.2	P.S. Ladder Track Left

PLATE B



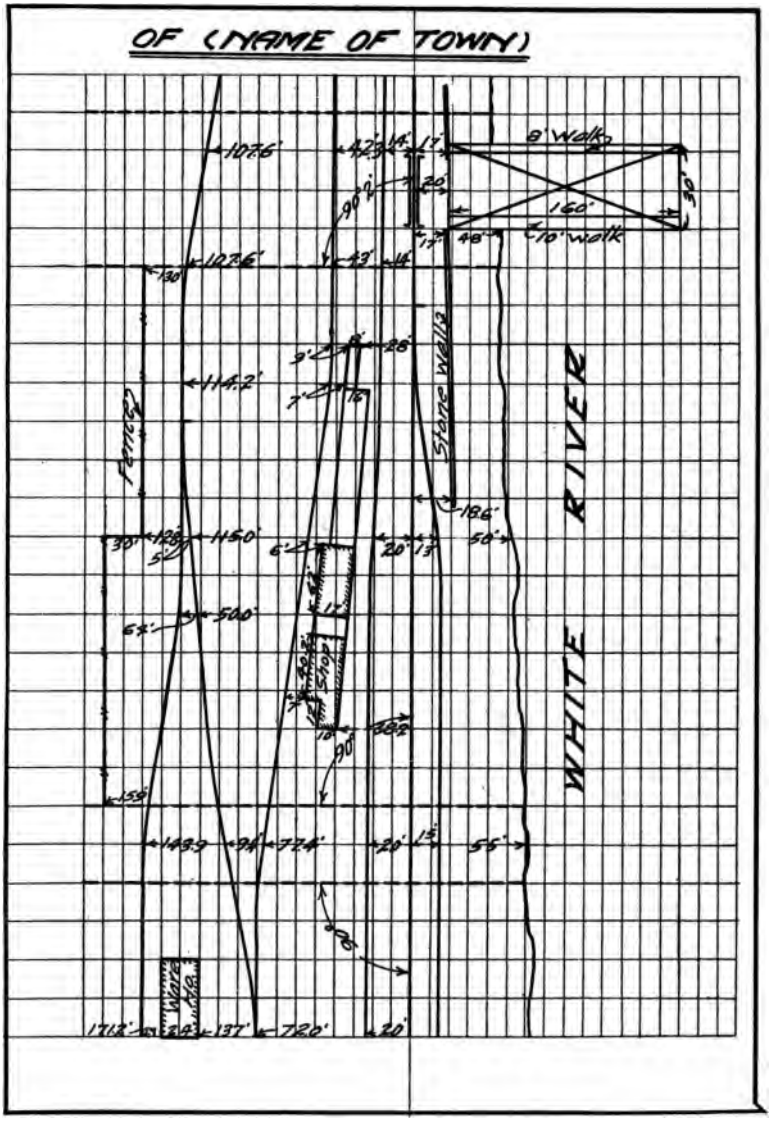
OF (NAME OF TOWN)
Spur 885' long
Store House
Tank
Frame
Res
Platform
Main Track
WHITE RIVER

PLATE C

STATION SURVEY

Station	Angle		Offset Sta. Dist
+11.5		West Prop. Line	
207			
+82.0		Center 68' Plank Xing.	
+54.0		East Line Bridge	3 - 4.4'L
+42.8		East Prop. Line	
+41.9		P.S. Track Right	
+27.8		West End Platform	
206	Chord Length 355.5'		
+90.2		P.S. on 3rd Track Left	
+82.5		P.F. Track Right	2 - 9.4'L
+42.0		End Stone Wall	
205		Fence Cor. Left	
+44.0		East End Bldg.	
			1 - 6.4'L
204			(Offsets are distance from Chord to Center of Track.)
+85.0		East End Bldg.	
Δ +56.0	4°22'R B.S.	Tangent Back. Approx P.C. Right	
+40.7		West Building Line	
203			
+59.1		East Bldg Line	
+23.0		P.F. on 2nd Track Left	
+14.0		West End Ware House	
202			
+44.4		P.S. on 2nd Track Left	

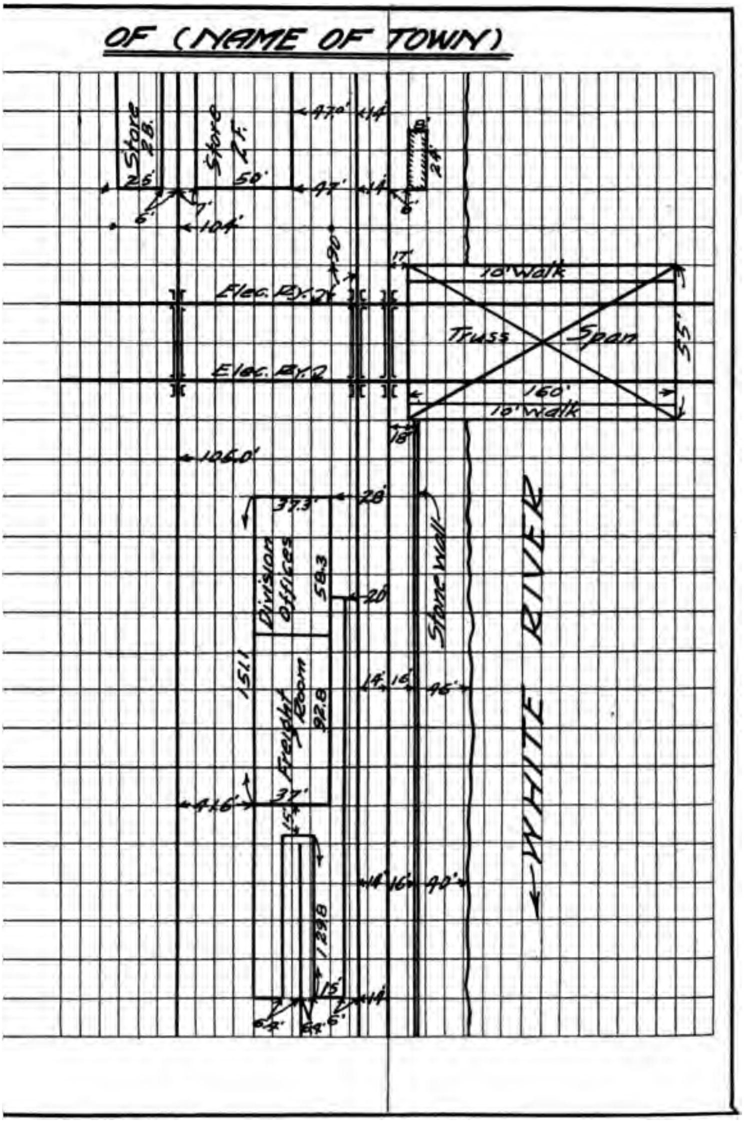
PLATE C


OF (NAME OF TOWN)
8' Walk
160'
30'
10' walk
48'
90°
20'
107.6'
42.3'
14'
17'
130'
43'
28'
114.2'
Fence
Stone Walls
18.6'
WHITE RIVER
30'
128'
50'
145.0'
6'
20'
13'
55'
6%
50.0'
Shop
38.2'
155'
143.9'
94'
77.4'
137'
72.0'
171.2'
Water Tank

STATION SURVEY

Station	Angle	
212		
+03.5		West Line Union Ave.
211		
+91.3		West Edge Bridge
+68.7		Center Line of Elec. Ry.
+63.7		Center Plank Xing. 16' long.
+58.2		Center Elec. Ry.
+35.8		End of Stone Wall
+23.5		End of Bldg's indicating Bldg Line
+20.1		West end Depot
210		
+73.0		End Depot Platform
209		
+69.8		East End Frt. Platform
+48.8		End Track Between Platform
208		
+24.2		End Depot Platform
4207+16.4	8°51'R To Form Tan. B.S. on 203+56.0	Approx P.T.

PLATE D


OF (NAME OF TOWN)
Store 28.
Store 27.
Elec. Ry. 2
Truss Span
10' Walk
160'
Division Offices
Freight Room
Stone Wall
WHITE RIVER

b. Bottom and top of tub.

c. Bottom and top of dam.

12. Run a line of levels along proposed route of pipe.

Level Notes

Level work consists in finding the relative elevations of a number of points and should be taken often enough, that, when plotted, a correct profile of the survey is secured.

For levels taken on maintenance-of-way work, the practice is as follows:

Locate a permanent point for a bench mark, describe location of the same and give datum plane used. The point should be so located that it is not likely to be disturbed, at least for a number of years.

Permanent bench marks should be placed every half mile along the course on stone culvert steps, bridge seats, and in the roots of large trees.

A description of the bench should be placed on the right-hand page opposite its elevation. Make the description so plain that there can be no question regarding the point used.

All elevations on tracks should be at the base of rail.

At every 200-ft. point along the track take side elevations at toe of slope and along the natural ground to right of way fence.

Take the plus to, and elevations of, all flow-lines of drains, ditches and sewers close to tracks; the grade lines of roads, etc.; measure height of bridges and take

profile of stream under bridge, showing contour of channel, distance between bents or piers and stage of water at date of survey, also maximum high-water marks.

Take plus to all viaducts and overhead bridges giving the exact clearance measured from top of rail to lowest point on overhead structure.

The accuracy of the level-work is affected by sunshine or wind and a note regarding the weather should be recorded on the right-hand page, such as "clear and cold," "cold and high wind," etc. The most accurate levels can be taken on a calm, cloudy day.

The notes on Plate E are copied from an actual field survey which was started from a bench mark, made by driving a spike into a telegraph pole 50 ft. to the left of Sta. 245 at an elevation of 100. The stations were marked on the right-hand rail with yellow keel.

The rodman held the rod on this spike and a reading of 3.74 ft. taken and recorded under the +R Column. $3.74+100.00=103.74$, the height of instrument. Readings of 4.36, 6.16, and 5.75 were then taken at the base of rail at Stations 248, 247, and 246 respectively and recorded in the −R Column. These readings subtracted from the H. I. give the elevations 99.38, 99.72 and 100.13 at base of rail, which were recorded in the column marked Elevation.

A turning-point was taken at Sta. $241+52.4$ and the above operations repeated.

In most cases it will be sufficient to read benches and turning-points to hundredths and all intermediate

PLATE E

STATION SURVEY

Sta	+Rod	H.I.	-Rod	Elev.	Remarks
B.M.	3.74	103.74		100.00	
248			4.36	99.38	
47	6.50	105.88	6.16	99.72	
46			5.75	100.13	
45			5.33	100.55	
44			5.00	100.88	
+18.8			4.73	101.15	R.R.Xing
43			4.64	101.24	
42			4.75	101.13	
+52.4	4.40	105.56	4.72	101.16	R.R.Xing
41			4.70	100.86	
+57.5			4.84	100.72	R.R.Xing
240			4.77	100.79	
39			4.77	100.79	
38			5.17	100.39	
37			5.23	100.33	
36			5.25	100.31	
35	4.95	105.21	5.30	100.26	
34			4.87	100.34	
33			5.03	100.18	
32			5.12	100.09	
31			5.43	99.78	
230			5.25	99.96	
29			5.25	99.96	
28			5.10	100.11	

PLATE E

LEVEL				NOTES	
B.M. Spike in pole 50' left of Sta 245					
	Track 6 L. 99.09		Track 4 L. 99.19	Track 2 R 99.84	
	120 99.4		40 100.25	Track 1 R 100.60	
			R.R. Xing 100.98	R.R. Xing 101.45	
				Track 1 R 100.91	
			R.R. Xing 101.21	R.R. Xing 101.65	
40 99.0	25 97.0		15 100.4	R.R. Xing 100.94	
60 98.8	25 97.0		15 100.0	15 100.10	
			50 99.2		
				Track 1 R. 100.81	
	40 96.2		10 100.2		
	40 98.0		12 100.0	14 101.0	30 101.1
35 100.5	21 100.8		15 99.1	14 Track 100.61	28 Track 101.11
			20 96.8	14 Trk. 100.96	28 Trk. 101.41

points to tenths, except readings on bridge seats, piers, etc., which should be read to hundredths.

Although the notes were taken from a survey made on railway maintenance work, the same form can be used on preliminary surveys, construction and sewer work, or on any survey where levels are run over a located line.

Do not make erasures in the notes. If an error is made, draw a line through the rejected figures. This shows exactly what was done and may clear up some obscure point later.

Check each page of notes by adding up the plus and minus rod readings and taking the difference, which should equal the difference in elevation between the starting and final points. This should be done on a scrap of paper and the final elevation marked "checked."

Stadia Survey Notes

If a survey be made by the stadia method, elaborate topography can be taken in a short time with a small party and with very little labor.

The stadia is extensively employed in drainage work, preliminary work of bridge location, traversing irregular areas, and all topographical surveys where a great degree of accuracy is not required.

Railroad engineers do not regard it with favor, for the reason that the notes require a great deal of reduction and are hard to record as the instrument man is transit man, leveler and topographer all in one. Consequently one set of notes must be devised to cover all three sets of readings.

If the system of notes recorded on Plate F, be adopted and the stadia method used on all preliminary surveys, the engineer would effect considerable saving of cost as the party would be very small.

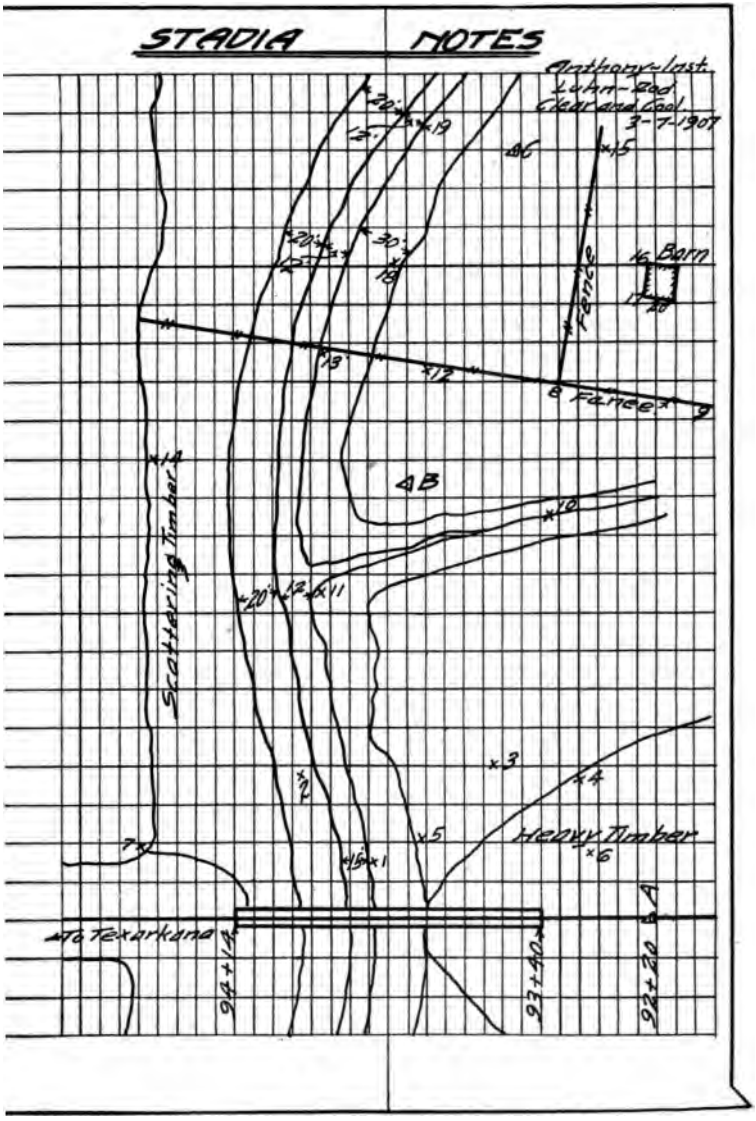
The stadia notes recorded in this book were taken from an extensive survey along the Arkansas River, where rapid progress was made. The notes were recorded very rapidly in the field and so arranged that the office computations were reduced to a minimum.

As indicated in the notes (Plate F), the transit was set up at hub A or Sta. 92+20 on the main line. The telescope was pointed down the track to Sta. 96×0.0, and this tangent, from Sta. 82+20, 10 Sta. back of instrument, to Sta. 96+00, 380 ft. ahead of instrument, was called the Zero Azimuth, and so recorded. Points 1, 2, 3, 4, 5, 6, 7 and hub B were turned from this azimuth. The number of the points should be recorded in Column 1 of the notes. The two points on the rod, intercepted by the stadia wires in the transit telescope, should be recorded in Column 2. This method of recording both rod readings is unusual, merely the difference usually being recorded. Should the instrument man make a mistake in figuring this difference, the blunder could not be located. With both readings recorded a check can be obtained at any time a distance is questioned. This is a very common mistake for a young engineer to make, and the two rod readings should be recorded, at least until the engineer has obtained a high degree of skill in stadia work. The difference between these two readings, multiplied by the constant of the instrument, equals the stadia distance from the instrument to the

PLATE F

Zero Azimuth = Tan. 82+20 to 96+00 looking towards Texarkana Ark					
Point	Stadia Dist / Correct Dist	Azimuth	Vert. Angle — Rod	Elev.	+ Rod Remarks
Sta 92+20 ΔA		0°00'	H.I. 101.86	96.56	5.3
1	6.18 / 4.42 175.6	10°10'	−2°47'	93.3	Edge Water
2	6.55 / 4.05 249.5	20°50'	−2°28'	94.3	" "
3	5.80 / 4.80 100.0	22°00'	−0°45'	100.6	
4	6.10 / 4.50 160.0	89°00'	−5°3'	96.6	Foot Knoll
5	10.0 / 4.56 44.0	18°20'	6.6	95.2	Top Bank
6	6.18 / 5.02 116.0	130°40'	−0°30'	100.9	
7	7.80 / 2.76 493.4	5°10'	+8°20'	173.2	Top Cliff
B	8.76 / 4.00 476.0	75°56'	−0°30'	97.72	Hub
ΔB		0°00'	H.I. 102.62		4.90
8	5.63 / 4.37 126.0	150°20'	+1°00'	104.8	Fence
9	8.60 / 6.00 260.0	165°30'	4.3	98.3	"
10	8.56 / 5.76 330.0	185°00'	−0°16'	96.0	Edge Water
11	9.26 / 5.00 426.0	298°30'	7.3	95.3	" "
12	5.91 / 4.69 122.0	105°50'	3.8	98.8	Fence
13	6.10 / 3.90 219.8	58°10'	−1°39'	96.3	Edge Water
14	7.42 / 3.00 441.5	350°00'	1.8	100.8	Foot Cliff
C	7.78 / 4.22 356.0	115°40'	+0°45'	107.39	Hub
ΔC		0°00'	H.I. 112.29		4.90
15	5.71 / 4.71 150'	180°00'	+0°50'	109.6	Fence
16	6.21 / 3.71 249.9'	220°30'	+1°00'	111.8	Cor. Barn
17	6.80 / 4.00 280'	221°00'			" "
18	6.00 / 4.97 245'	310°20'	8.9	103.3	Top Bank
19	5.80 / 4.02 176.7	2°20'	−4°48'	97.4	Edge Water.

PLATE F


STADIA NOTES
Anthony-last.
Lahn-God
Clear and Cool
3-7-1907
Barn
Fence
Fence
AB
Scattering Timber
Heavy Timber
To Texarkana
94+14
97+40
92+20 B.A

rod. This distance after corrections have been applied, should be recorded on the right-hand side of the second column under the heading, "Correct Distance." The angle turned from the zero azimuth should be recorded in Column 3 headed Azimuth. Record the vertical angle in Column 4. Should the instrument man be able to read the rod with the telescope level, that is, with a vertical angle of zero, the reading could be considered as a level reading and recorded in Column 4 as a $-$R reading in place of a vertical angle. This rod reading subtracted from the H. I. would give the elevation of the point and thus save several reductions. The fifth column is used for the elevations which are computed in the office, leaving the sixth column for remarks.

The instrument is then taken to hub B, the telescope set on hub A, with the A vernier reading 180° different from its previous reading on this line between hub A and hub B. This places the instrument on a parallel azimuth. Set points 8, 9, 11, etc., the same as above.

All points numbered or lettered on the left-hand page should be indicated on the sketch on the right-hand page in their relative positions. No two stadia points on same sketch should be designated by the same letter or number. Whenever possible start stadia surveys from some definite point on the track, with some point on the survey tied to a mile-post, or some established line.

On small surveys it is not necessary to apply the correction to the stadia distance as it is very small and is only applied where the survey covers an extensive

area. The object of the survey should determine whether or not this correction should be made.

Curve Rerunning and Spiral Notes

Where a railroad track has been in use for a number of years it is likely to have a great many kinks or bends in the tangents and irregularities in the curves, making it desirable that the track should be given a thorough realinement, as the alinement of the track plays a very important part in the economy of maintenance and the safe running of the trains.

The effect of traffic is to cause the track to shift on both tangent and curves, developing swings and bends which cause the cars to surge and sway and may in time cause serious derailments.

Every effort should be made to remove all sharp, short swings in tangents and to secure simple curves. Whenever it is necessary to compound, the number of compounds should be made as few as possible and the differences in the degree of curves used be made as small and slight as possible. Changing the roadbed slightly may give an opportunity to change the adjacent tangents in such a way as to simplify the curve.

All curves of 1° 30′ and over should be spiraled; where the variation in compound curves is greater than 1° 30′, a spiral should also be inserted.

The length of spiral in feet should be equal to the degree of curve multiplied by fifty. However, a great many things should be considered in selecting the length of spiral; such as the speed of trains passing

PLATE G

CURVE RERUNNING

Little Rock West Curve #10

Inst.	B.S. - F.S.	1 Angle	5 Angles	Eve Angle	Chord
A.	Tan. B.	2°00'00"	10°00'00"	2°00'00"	381.0
B.	A. C.	7°00'00"	34°58'00"	6°59'36"	352.6
C.	B. D.	7°22'30"	36°52'00"	7°22'24"	383.4
D.	C. E.	7°08'30"	35°42'30"	7°08'30"	341.7
E.	D. Tan.	1°50'30"	9°11'30"	1°50'18"	
		Δ = 25°21'00"			
		P.S. = Traverse point A - 6a 66 = Sta 0.0			

Sta.	Align.	Def. Angle	Total Angle		Remarks.
5		4°01'30"			
+50		3°31'15"			
4		2°01'00"			
+50		2°30'45"			
3		2°00'30"			
+50		1°30'15"			
2		1°00'00"			
+50		0°29'45"			
Δ1+0.83	P.C.C.	0°20'20"	1°01'00"	B.S. Sta. 0+00 Turn 0°40'40"	
+80		0°13'00"		Δ = 1°01'40"	
+60		0°7'00"	Spiral	L = 100.83	
+40		0°3'00"		0 = .15 0 = 2	
+20		0°01'00"			
Δ 0+00	P.S. R	0°00'00"	(Curve right)		

PLATE G

AND SPIRAL NOTES

∠ Angle	∠ Sin.	∠ Cos.	Sin Dist.	Cos. Dist.
2° 00' 00"	.03490	.99939	13.30	380.77
8° 59' 36"	.15632	.98771	55.12	348.27
16° 22' 00"	.28178	.95948	108.03	367.86
23° 30' 30"	.39889	.91700	136.30	313.34

	Sin Dist		Cos. Dist
	13.30	B	380.77
	68.42	C	729.04
	176.45	D	1096.90
	312.75	E	1410.24

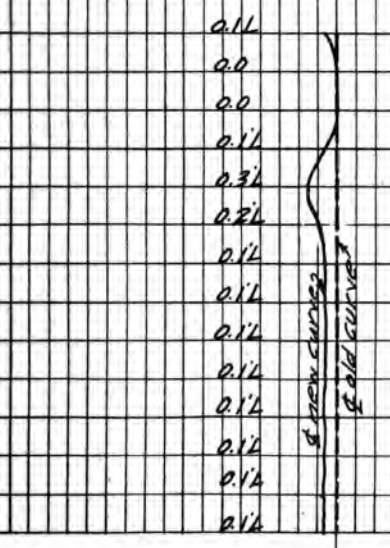
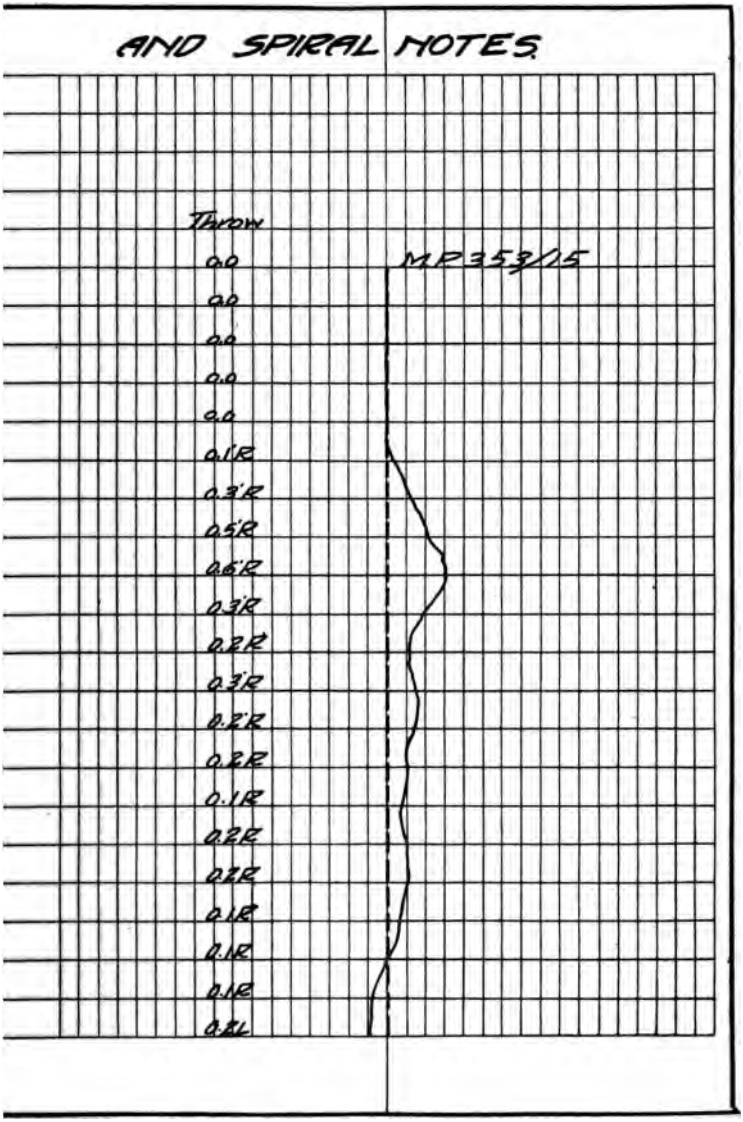


PLATE H

CURVE RERUNNING

Sta.		Def. Angle	Total Angle		Remarks
			Spiral backed in		B.S. on Tan.
Δ+57.86	P.T.	0° 00' 00"		Δ = 1° 01' 00"	
+37.86		0° 01' 00"	Spiral	L = 100.83	
13+17.86		0° 03' 00"		o = .15	
+97.86		0° 07' 00"		Δ = 2	
+77.86		0° 13' 00"			
12+57.03	P.C.S.C.	0° 20' 00"	1° 01' 00"		
Δ 12+57.03	"	11° 39' 30"	23° 19'		
12		11° 05' 00"			
+50		10° 34' 45"			
11		10° 04' 30"			
+50		9° 34' 15"			
10		9° 04' 00"		Circ. Curve	Δ = 23° 19' 00"
+50		8° 33' 45"			D = 2° 01' 00"
9		8° 30' 00"			L = 1156.2
+50		7° 33' 15"			
8		7° 03' 00"			
+50		6° 32' 45"			
7		6° 02' 30"			
+50		5° 32' 15"			
Δ 6		5° 02' 00"		B.S. Sta. 1+0.83	
5+50		4° 31' 45"			

PLATE H


AND SPIRAL NOTES
THROW
0.0
0.0
0.0
0.0
0.0
0.1R
0.3R
0.5R
0.6R
0.3R
0.2R
0.3R
0.2R
0.2R
0.1R
0.2R
0.2R
0.1R
0.1R
0.1R
0.2L
MP 353/15

around the curve, distance between curves, the amount and cost of work required to change the track, etc. Even a very short spiral is better than no spiral at all.

On single track, monuments made of 1 1/2 to 2-in. iron pipe or pins, 3 to 4 ft. long should be driven in the center of the track at Points of Curve and Tangent, Points of Spiral and Compound Curve, and about 500 ft. around the curves, recording all curve data as shown on Plates G and H, so that any engineer can rerun the curve at any future date without recalculating it.

The curve data given on Plates G and H were taken from a field-book of the Missouri Pacific and Iron Mountain Railway, and are a very good example of how the field notes should be recorded. The data recorded at the top of Plate G should be the information collected from which the functions of the curve are figured, and will vary with the different methods used to determine the functions of the curve.

Some engineers run the tangents to their intersection, read the intersection angle, or $\triangle$, and measure the external distance; while others prefer to traverse the curve and figure the functions of the curve from the deflections taken around the curve and chord lengths between traverse points.

As indicated in the notes given on Plates G and H, a Talbot spiral was used at each end of the curve. To any one familiar with the elements of curve work, the notes are self-explanatory, with the exception of the nomenclature used, which is as follows:

P.S. = Point of Spiral (add R. or L. for right or left).

P. C. C. = Point of spiral Compounded with circular Curve.

P. C. S. C. = Point where circular curve compounds with spiral.

P. T. = Point where spiral joins tangent.

$\triangle$ = Central angle.

L = Length of curve.

a = Rate of change of the degree of spiral pr 100′ of length.

o = Offset between the initial and the parallel tangents.

Use the same form of notes for preliminary curve running.

Construction Cross-section Notes to be used in the Calculation of Earthwork

After the center line of a new road has been located, the field corps should take the first steps toward finding the cubical contents of the proposed cut and fill by taking cross-sections at every 100-ft. station and all intermediate plusses where the surface of the ground is so irregular and broken that a cross-section is necessary.

The engineer should so place his cross-sections that the solid included between two cross-sections is a prismoid or very nearly so.

A prismoid is a solid having 2 plain parallel ends and bounded on the sides by a surface such as would be generated by a straight line moving on the end

sections or directors. To do this the ridges and hollows should be observed very closely, and cross-sections taken wherever they vanish, or wherever they run diagonally across the line.

As the contractor is usually paid for excavation, the engineer should take sections more numerous along the cut than along the fill.

At the time the road is cross-sectioned, slope stakes and grade stakes should be set.

A slope stake is a stake set at each station at the point where the side slopes meet the ground.

A grade stake is a stake set at the point where the plane of the roadbed intersects the ground surface.

The text books dealing with railroad construction give a great many formulas for locating slope and grade stakes, but an engineer will make better time in the field and get reliable data if all formulas are disregarded and the stakes set by trial.

The success of the trial-method depends upon the ability of the instrument man to keep a good set of notes and he should be very exact regarding distance and elevation of all points between slope stakes, for they will be inaccessible to measurement when the grading is once started.

Before the field work is started the cross-section book should be prepared as far as possible in the office. The station numbers and elevation of proposed grade should be placed in the field book, leaving a line between each station for turning points. If the profile indicates a very rough section, several lines should be left between station numbers for intermediate cross-sections. A study of the profile and the

engineer's knowledge of the ground should show about where these lines should be left open.

The book being prepared and each column headed as indicated on Plate I, the actual field work is started. In this case the party consisted of an instrument man, two rod men and one axe man. The instrument was set up at Station 2 and a reading of 12.98 taken on a B. M. having an elevation of 104.63; $104.63 + 12.98 = 117.61$, the H. I. The rod was then held on the ground at Sta. 0.0 and a reading of 12.1 taken and recorded in the − R Column; $117.61 - 12.1 = 105.5$, the elevation of the ground at Sta. 0.0. As the grade at this point was 96.5 (Column 2 taken from profile) and with an elevation of ground of 105.5, the difference or 9.0 ft. would be the cut at this point. Record on right-hand page as 9.0/C meaning a cut of 9.0 ft, on center of proposed line at Sta. 0.0.

Knowing that a slope of 1 to 1 and a 20-ft. roadbed was to be used in all cuts the slope stakes were set by holding a tape at right angles to the center of the roadbed and the rod man moving right or left along the tape until the rod rests on the point where the cut $+1/2$ roadbed = reading on the tape. This is the point where the edge of cut intersects the ground surface.

Where the cross-sections indicate the fact that you have passed from cut to fill, locate the points of 0.0 cut and fill, driving grade stakes at these points flush with the ground and color the top of the stakes blue or red. A study of the notes will show the grade stakes between Stations 3 and 4.

Through embankment an 18-ft. roadbed was used

PLATE I

Construction Cross Sections
Waverly Cut Off.

Sta.	+Rod Grade	H.I.	-Rod	Ground	Grade Rod
0	12.98 96.5	117.61	12.1	104.63 B.M. 105.5	+21.1
1	97.0		6.8	110.8	+20.6
+50	97.25		2.0	115.6	+20.3
2	97.5		7.9	109.7	+20.1
3	98.00		11.3	106.3	+19.6
T.P.	0.24	106.93	10.92	106.69	
+38	98.19		6.7	100.2	+8.7
+73	98.37		8.5	94.4	+8.5
4	98.5		13.9	94.0	+8.4
T.P.	0.30	94.40	12.83	94.10	
+45	98.72		1.8	92.6	-4.3
5	99.0		2.4	92.0	-4.6
6	99.5		3.4	91.0	-5.1
7	100.0		4.2	90.2	-5.6
8	100.0		4.2	90.2	-5.6

PLATE I

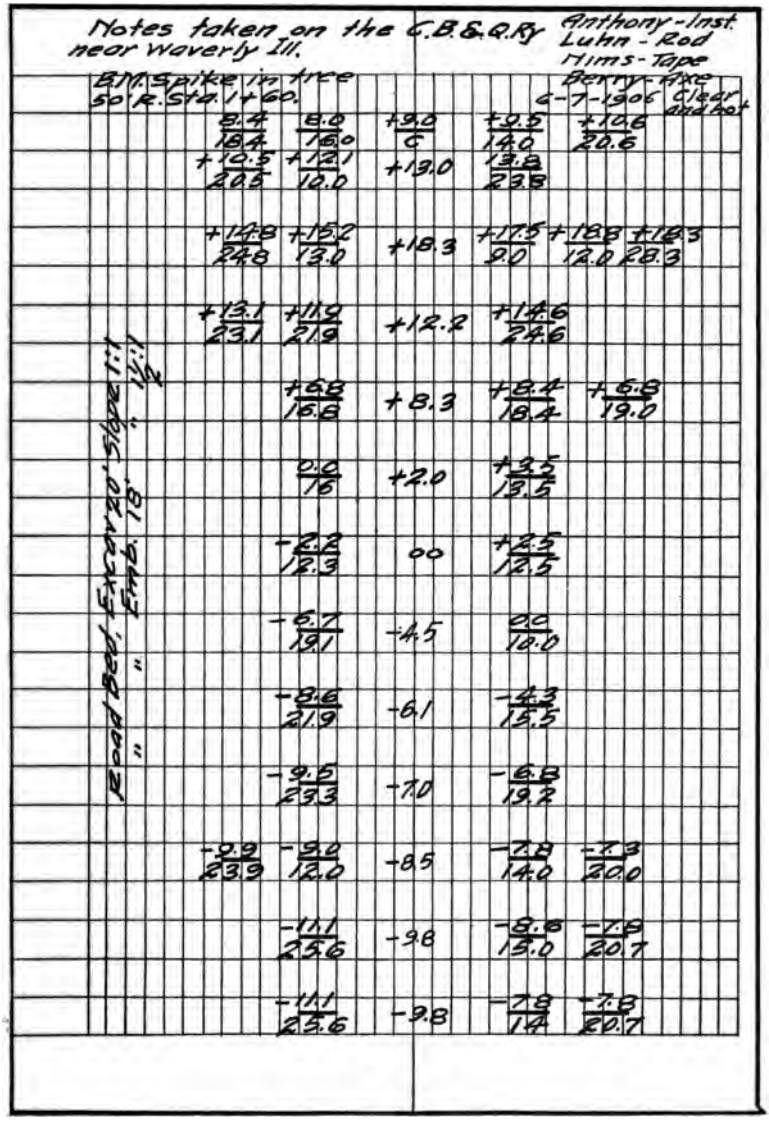

Notes taken on the C.B.&Q.Ry near Waverly Ill.
Anthony - Inst.
Luhn - Rod
Hims - Tape
Benny - Axe
6-7-1906 Clear and hot
B.M. Spike in tree 50' R. Sta. 1+60.
Road Bed, Excavation, Slope 1:1
" " Emb. 18", 1½:1
" " 2:1

PLATE J

		Base Line A-B			
Sta	+Rod	H.I.	-Rod	Elev.	Remarks
	3.53	107.11		103.58	Bottom of Gravel Pit.
C			1.5	105.6	"
25'R			1.3	105.8	"
50'R			3.3	103.8	"
75'R			3.1	104.0	"
100'R			2.8	104.3	"
125'R			1.1	106.0	"
150'R			3.3	103.8	"
175'R			2.5	104.6	"
200'R			1.7	105.9	"
		Base Line A'-B'			
	4.83	145.34		140.51	Top of cliff
175'L			5.8	139.5	"
150'L			6.2	139.1	"
125'L			6.9	138.4	"
100'L			8.4	136.9	"
75'L			9.2	136.1	"
50'L			6.7	138.6	"
25'L			4.9	140.4	"
C'			7.1	138.2	"

Elevations taken on line C-C' and recorded as reading Right of A-B and Left of A'-B'.

PLATE J

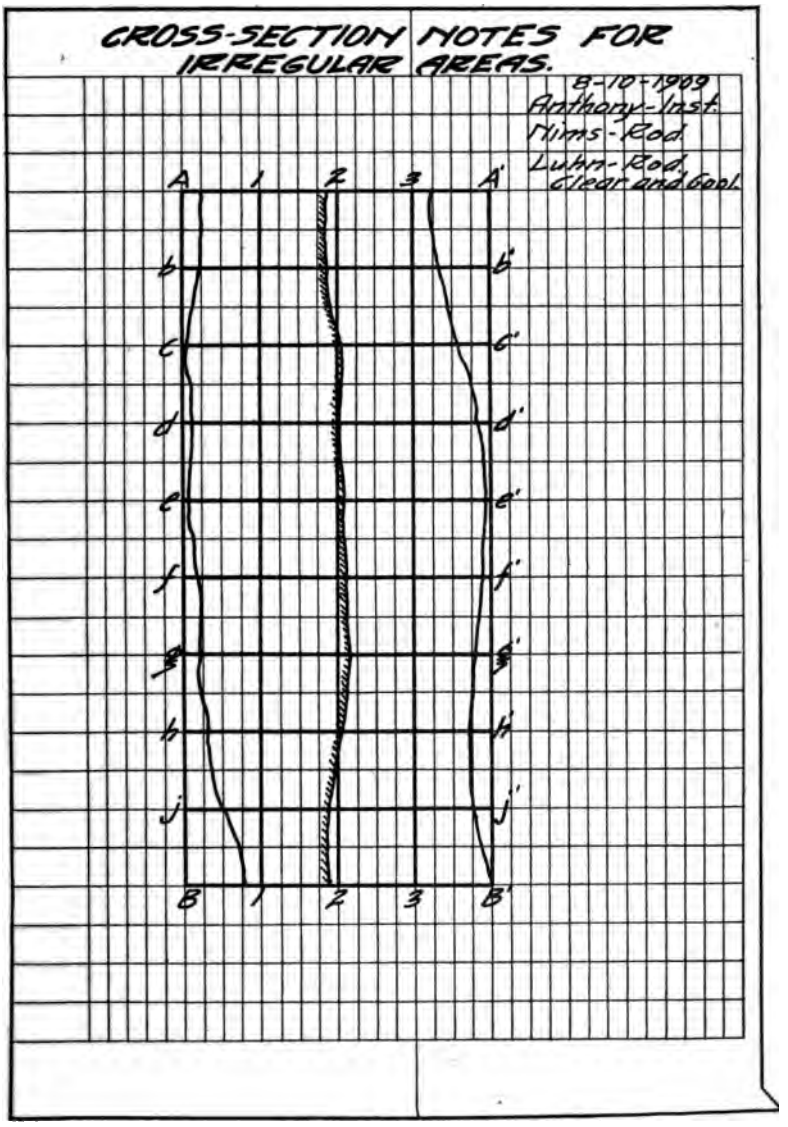

CROSS-SECTION NOTES FOR IRREGULAR AREAS.
8-10-1909
Anthony-Inst.
Hims-Rod
Luhm-Rod
Clear and Cool
A
1
2
3
A'
b
b'
c
c'
d
d'
e
e'
f
f'
g
g'
h
h'
j
j'
B
1
2
3
B'

PLATE K

Sta.	+ Rod	H.I.	- Rod	Elev.	Remarks
B.M.	3.53	107.11		103.58	Bottom of Gravel Pit
			1.5	105.6	"
C+00 1+25			1.3	1058	"
C+00 1+50			3.3	103.8	"
C+00 1+75			3.1	104.0	"
C+00 2+00			2.8	104.3	"
C+00 2+25			1.1	106.0	"
C+00 2+50			3.3	103.8	"
C+00 2+75			2.5	104.6	"
C+00 3+00			1.2	105.9	"
B.M.	4.83	145.34		140.51	Top of Cliff
C+00 3+25			5.8	139.5	"
C+00 3+50			6.2	139.1	"
C+00 3+75			6.9	138.4	"
C+00 4+00			8.4	136.9	"
C+00 4+25			9.2	136.1	"
C+00 4+50			6.7	138.6	"
C+00 4+75			4.9	140.	"
C+00 5+00			7.1	138.2	"
C+20 2+50	Large Rock to be removed				
D+40 3+20	24" Red Oak Tree to be removed				
E+20 4+10	18" " " " " "				"
E+30 3+75	20" " " " " "				"

PLATE K

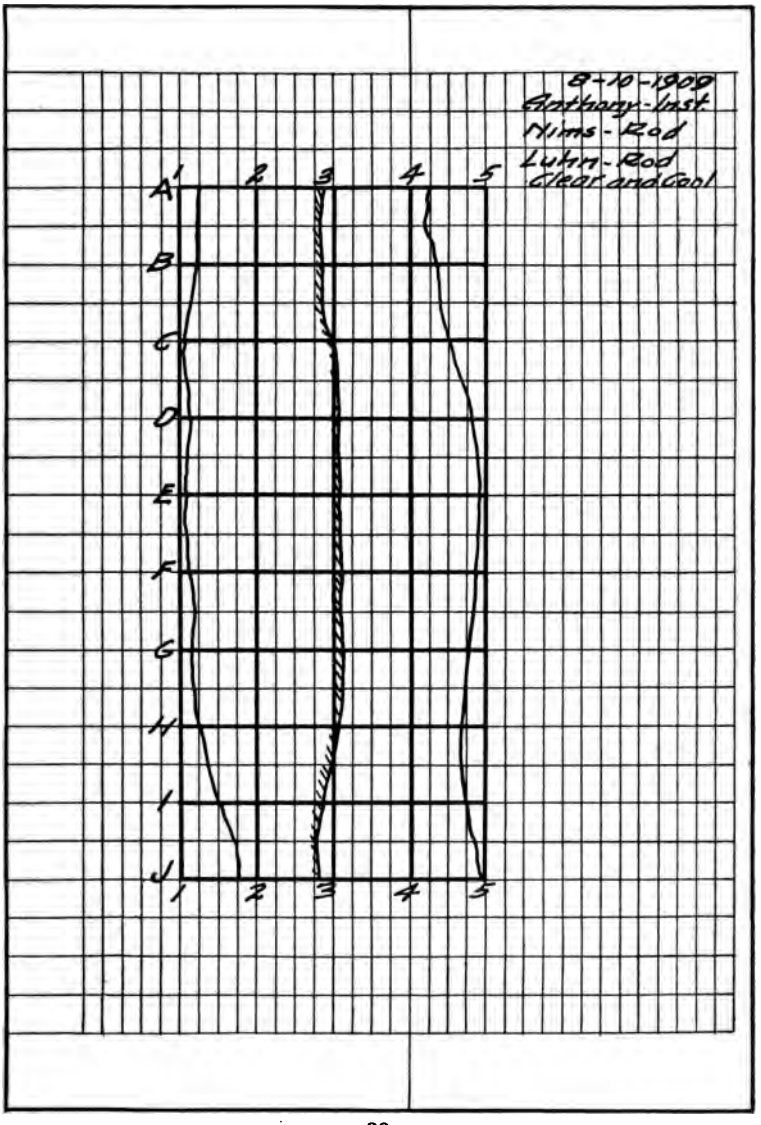

8-10-1909
Gathany-Inst.
Nims-Rod
Lutin-Rod
Clear and Cool
A
B
C
D
E
F
G
H
I
J
1
2
3
4
5

PLATE L

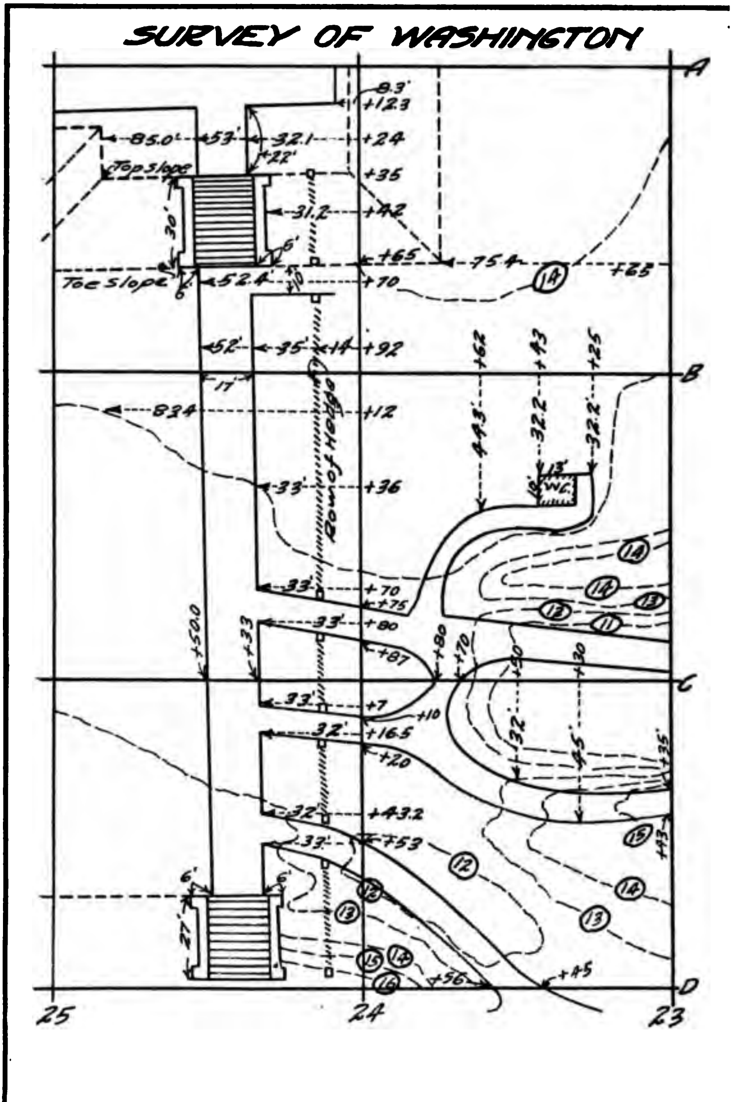
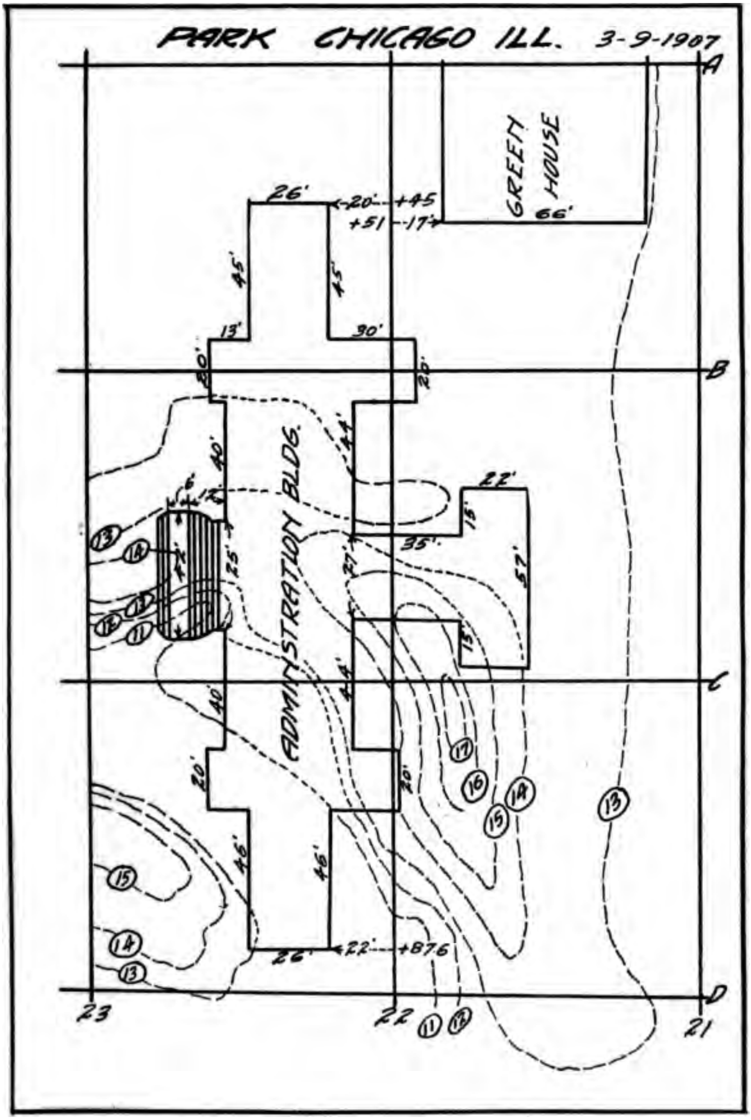
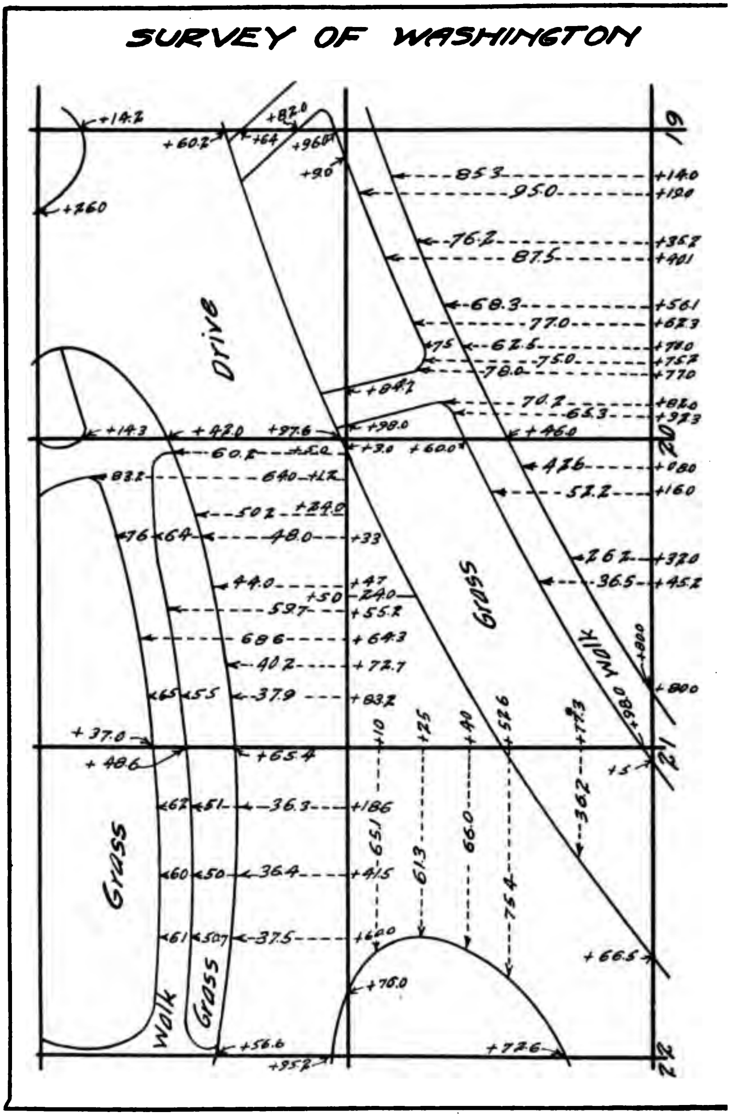
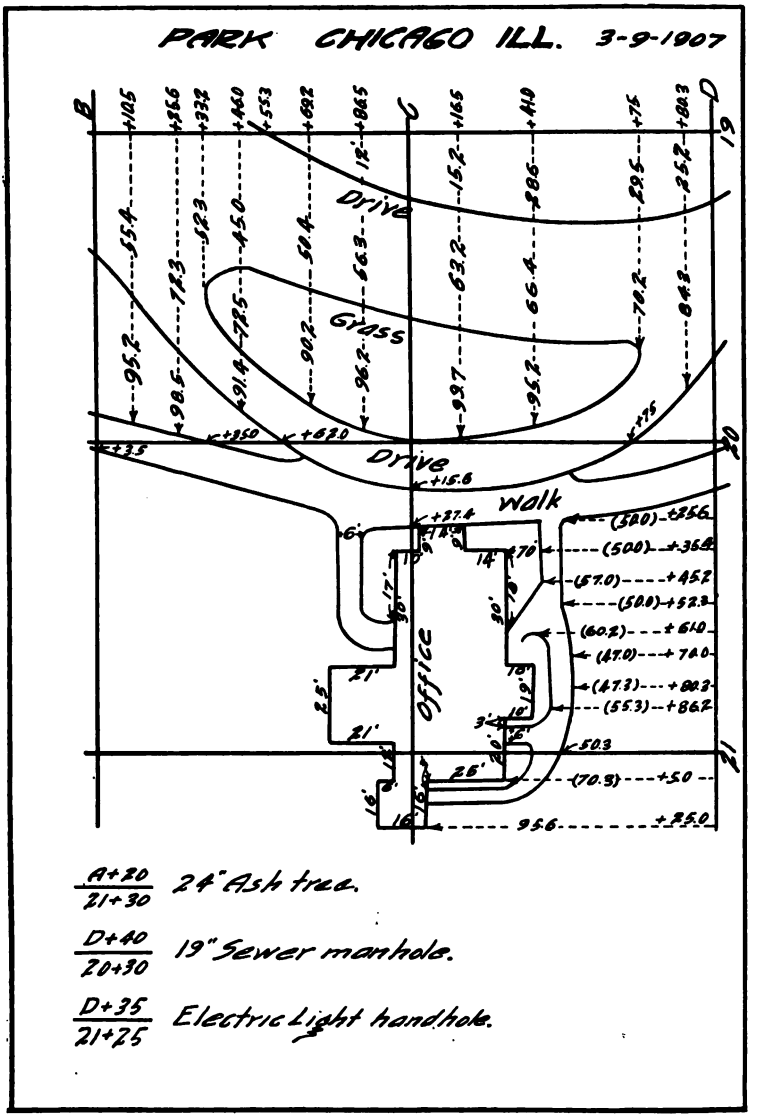

SURVEY OF WASHINGTON
A
B
C
D
25
24
23
Top Slope
Toe Slope
Row of Hedge
W.C.
85.0'
53'
32.1
+24
+12.3
+35
31.2
+42
+65
75.4
+70
52.4'
52'
35'
14'
+92
17'
83.4
+12
+36
+50.0
+80
+87
+7
+10
+16.5
+20
+43.2
+53
+56
+45
6'
30'
27'

PLATE L


PARK CHICAGO ILL. 3-9-1907
GREEN HOUSE
66'
26'
20'
+45
+51
17'
45'
45'
13'
30'
20'
20'
ADMINISTRATION BLDG.
40'
22'
15'
35'
57'
15'
40'
20'
20'
46'
46'
26'
22'
+87.6
A
B
C
D
23
22
21
13
14
13
12
11
17
16
15
14
13
15
14
13
11
12


SURVEY OF WASHINGTON
Drive
Grass
Walk
Grass
Grass
Walk
19
20
21
22
+14.2
+26.0
+60.2
+82.0
+64
+96.0
+9.0
85.3
+14.0
95.0
+19.0
76.2
+36.2
87.5
+40.1
68.3
+56.1
77.0
+62.3
+75
62.5
+72.0
75.0
+75.7
78.0
+77.0
+84.7
70.2
+82.0
63.3
+97.3
+14.3
+42.0
+97.6
+98.0
+46.0
+3.0
+60.0
47.6
+08.0
57.2
+16.0
60.2
64.0
83.2
50.2
+24.0
76
64
48.0
+33
26.2
+32.0
36.5
+45.2
44.0
+47
+50
24.0
59.7
+55.2
68.6
+64.3
40.2
+72.7
65
55
37.9
+83.2
+80.0
+98.0
+37.0
+48.6
+65.4
+10
+25
+40
+52.6
+77.3
+5
62
51
36.3
+18.6
65.1
61.3
66.0
75.4
36.2
60
50
36.4
+41.5
61
50.7
37.5
+60.0
+66.5
+76.0
+56.6
+95.2
+72.6



A+20 / 21+30 24" Ash tree.

D+40 / 20+30 19" Sewer manhole.

D+35 / 21+25 Electric Light handhole.

with a slope of 1 1/2 to 1. The slope stakes were set by making the fill +1/2 fill +1/2 roadbed = reading out from the center line on the tape.

When the engineer desires cross-sections of barrow-pits, steam shovel cuts, gravel pits, etc., where extreme accuracy is desired, proceed as follows:

Enclose the area to be cross-sectioned in a rectangle. Subdivide this rectangle into squares, the size of which depends upon the character of the surface. Using sides of the rectangle as base lines, stake out the squares, placing stakes at every subdivision point. Take readings at every subdivision point and such intermediate readings as are necessary to show all breaks in the surface. Record notes as shown on Plates J or K; these being two different methods of recording the same data.

This system of notes can be applied very well to the taking of topography. The land to be surveyed should be divided into squares of any desired size and the information taken and recorded as indicated on Plates L and M.

Plates L and M are copies of part of the square line survey of Washington Park, Chicago, made by the South Park Commissioners. All the parks in the South Park System are surveyed in this manner, the lines being so monumented that they can be relocated and used year after year, giving an exact tie between all surveys. The use of 100-ft. squares will give the best results for topography; while 27-ft. squares are used extensively when yardage is to be computed.

Transit Notes

The engineer is often called upon to make a great many small surveys to be used for bridge location, change of channel of some water course, change of alinement, etc., where a simple survey with a transit will give all the information required for a complete report.

The notes recorded on Plate N were taken from a survey made on the St. Louis, Iron Mountain and Southern Railway in connection with a proposed change of line near Riverside, Mo., and are embodied in this text for the reason that this form could be used very nicely on any of the above-named surveys. Notes of this character should not be used on a survey of any magnitude, where a topographer should be provided for this purpose.

The distances along the track are given in Column 1, from Sta. 105+00 to Sta. 120+50, with all plusses recorded. Column 2 should be used to designate the character of each hub driven, such as P.C., P.T., etc. Deflections right or left from each hub and around curves are recorded in Column 3. Total angle turned recorded is in Column 4. Calculated bearing in Column 5. Take the magnetic bearing as a check on the calculated bearing, and record in Column 6. Record all topography on the right-hand page, taking contours with hand level or stadia.

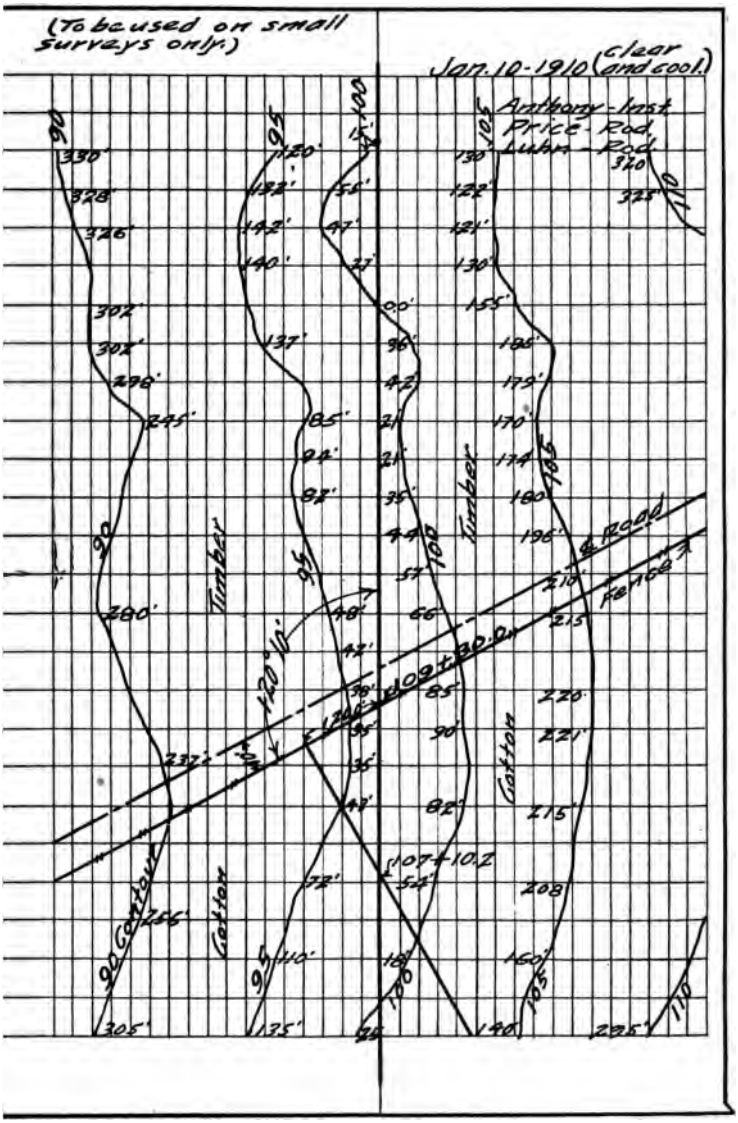
Hydrographic Surveying

Any survey made upon or connected with a body of water is called a hydrographic survey. The water

TRANSIT NOTES FOR LOCATION.

Sta.	Alignment	Def. Angle	Total Angle	Cal. Bearing	Mag. Bearing
Δ+50	P.T.	3°07.5'	6°15'	N.41°45E.	N.36°40'E.
120		2°52.5'			
119		2°22.5'		R 5224.65'	
118		1°52.5'		Tan. 312.32	
117		1°22.5		L.C. 625'	
116		0°52.5'			
115		0°22.5'			
Δ+25.0	P.C. 1°R.				
114					
113					
112					
111					
110					
Δ+75.0	P.T.	7°30'	15°00'	N35°30'E	N30°30'E
+50		7°00'			
109		6°00'		R1432.69	
Δ+50	P.O.C.	5°00'		Tan. 188.61	
108		4°00'		L.C. 375	
+50		3°00'			
107		2°00'			
+50		1°00'			
Δ106+00	P.C. 4°L				
Δ105+00	P.O.T.			N.50°30'E.	N.45°25'E.

PLATE N


(To be used on small surveys only.)
Jan. 10-1910 (clear and cool.)
Anthony - Inst.
Price - Rod.
Lubbock - Rod.
Timber
Timber
Cotton
Cotton
120 "10"
107 + 10.2

may be still or running. The survey may be made to collect data for a report on any of the following topics:

1. The location of channels.
2. The direction and velocity of currents.
3. The volume of scour or fill on the bottom and the study of sand waves.
4. The determination of depths for mapping and navigation purposes.
5. The location of rocks, sand bars, signals, etc.

The notes recorded on Plates O and P were taken from a survey made on the Arkansas River to secure data for mapping the topography around the M. H. E. L. Ry. bridge with the idea of perfecting plans for the protection of the bridge and tracks from overflows and washouts, which were occurring at more or less regular intervals. The survey was started by marking 100-ft. stations on the right-hand base of rail for two miles each side of the bridge; at the same time plusses of any importance were taken. From the track, which was given a zero azimuth, fixed points of reference, for the survey, were set along each bank of the river and accurately located by triangulation from the track as the preliminary base line. From these fixed points, or hubs, side shots were taken with the stadia, along the channel of the river and all ditches and streams draining into the river; at the same time angles were turned to sand bars at enough points to accurately fix their location in the river.

The triangulation work for the location of the reference points, or hubs, does not differ materially from that for a topographical survey. The only difference

being, that the points should be so placed that they can be used for a topographical survey along the shore and at the same time fit in the scheme devised for sounding the river, etc.

The soundings recorded on Plate P, were taken by sounding from a boat at the intersections of ranges established between hubs on the shore, and lines established by turning an angle from the zero azimuth at some fixed point on the shore or on the track. A sketch should always be prepared showing how and where the soundings were taken, as there are a great many systems of ranges used, and they are best explained by a sketch showing their location.

On Plate Q is a sample of notes taken from a survey made by the South Park Commissioners along the shore of Lake Michigan at Jackson Park, Chicago. The notes show the system of taking soundings from the Casino Pier, where the scour and fill at the bottom of the lake is studied and the soundings repeated at the same point each year. The soundings were taken at the intersections of ranges established every 100 ft. along the pier and lines established by turning angles from known base lines on the shore. The lines E′ and J′ also line 22 are a few of the lines making up a system of squares which have been used in the Park since 1895 and are used exactly the same as the base lines indicated on Plates L and M, the survey of Washington Park, Chicago.

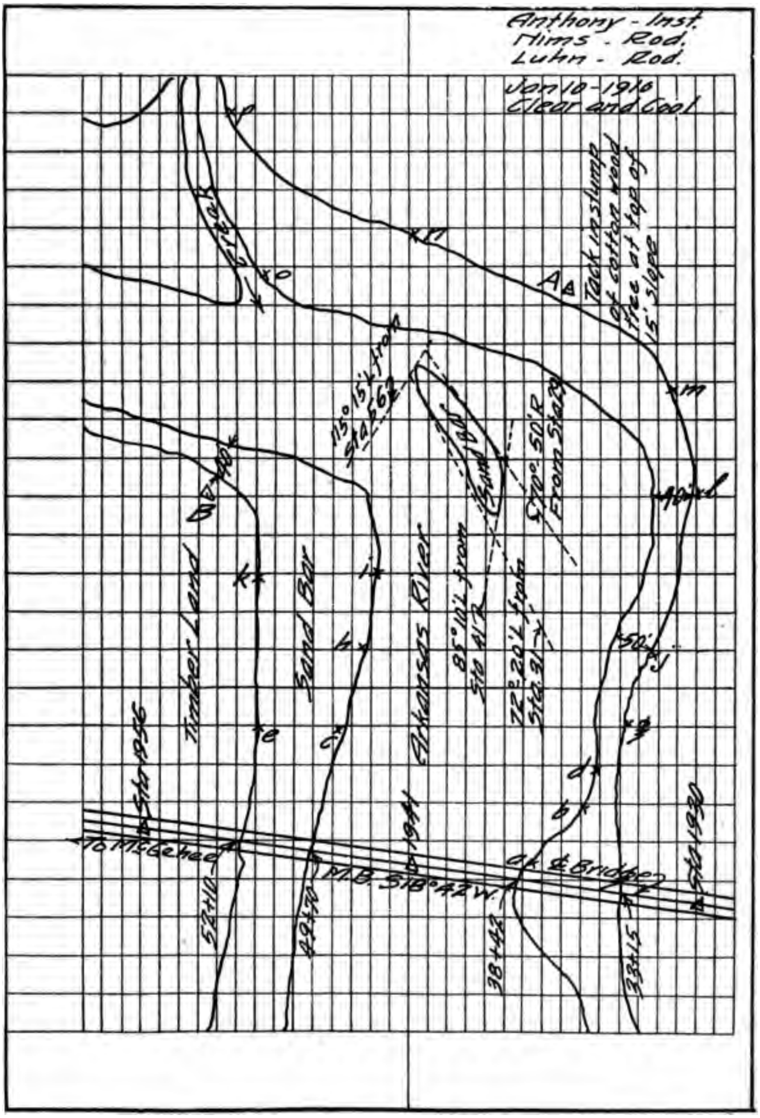
HYDROGRAPHIC SURVEY.

Hydrographic Survey of the Arkansas River near the Ark. River Bridge. M.H.&L.Ry.

Zero Azim = Tangent Sta. 1930 to 1950 towards McGehee.

Point	Inst. at	Azim	Dist	Remarks.
0	1941	170°15'	220'	Sand Bar
b		161°07'	315'	
c		70°50'	510'	
d		150°08'	410'	
e		40°50'	640'	Top of Bank
f		173°30'	460'	
g		150°00'	520'	
h		81°20'	980'	Sand Bar
i		81°00'	1100'	
j		139°50'	600'	Top of Bank
k		72°05	1150'	
l		110°17'	1020'	
B		74°00'	1320	Top of Bank So. side river
m		101°02'	1320'	Top of Bank
A		90°35'		Top of Bank
A	1930	62°17'		
A	1956	130°06'		
B	A	321°12'	1025'	
n		12°20'	250'	
o		351°05'	335'	Top of Bank
p		15°10'	700'	Edge Water

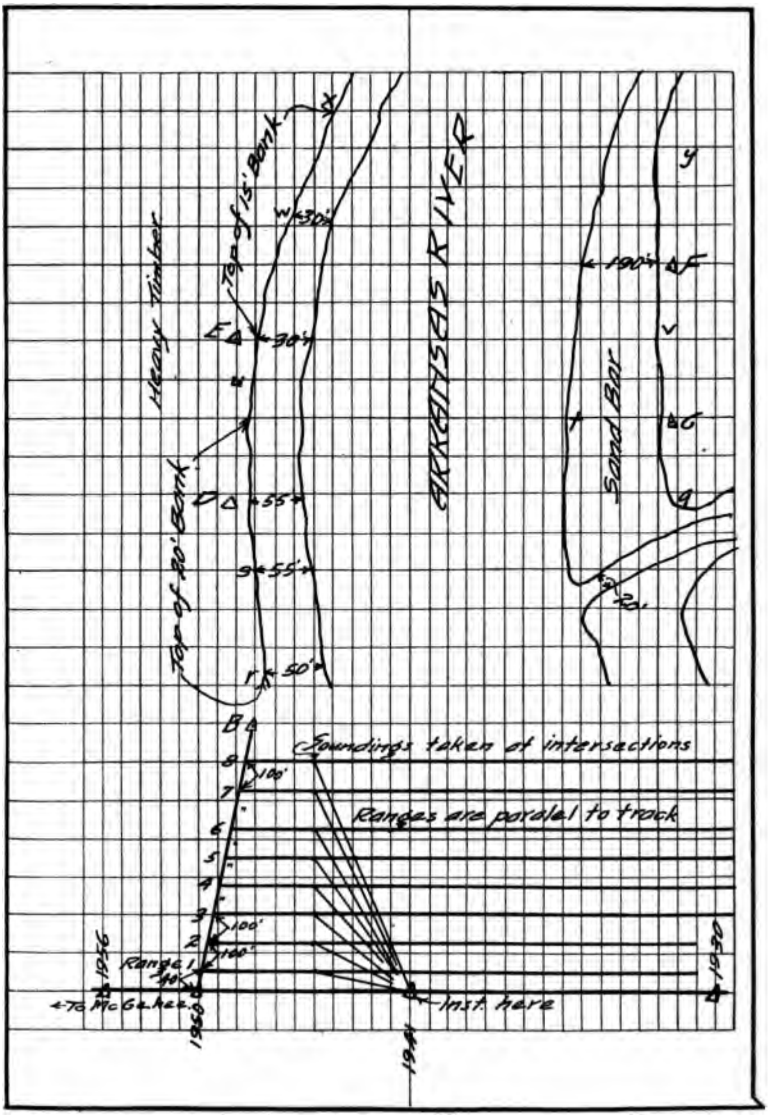
PLATE O



Anthony - Inst.
Hims - Rod.
Luhn - Rod.
Jan 10-1916
Clear and Cool
Tack in stump of cotton wood tree at top of 15' slope
Timber Land
Sand Bar
Arkansas River
To McGehee
M.B. S18°42'W.
52+10
49+70
38+42
33+15

Point	Inst at	Azm	Dist (Stadia)		
q	A	16°03'	765'	Bank of Creek	
r		331°45'	1120'	Top of Bank	
C		20°03'	915'		
s		339°13'	1205'		
D		345°09'	1295		
D	C	274°18'	695		
t		281°10'	225'	Sand Bar	
u		295°52'	690'	Top of Bank	
v		20°20'	375'		
E		308°37'	725'		
F		25°21'	1015'		
E	F	265°10'	985'		
w		280°22'	810'		
x		291°30'	795'		
y		45°55'	175'		
Range	Inst at	Azm	Sounding		
1	1941+00	7°00'	8.6'	(See sketch for	
2		22°00'	10.1'	location of Range	
3		32°10'	12.3'	Lines)	
4		40°20'	10.2'		
5		52°12'	14.3'		
6		56°21'	13.2'		
7		60°23'	12.2'		
8		70°40'	10.3'		

PLATE P



Heavy Timber
Top of 15' Bank
Top of 30' Bank
Sand Bar
Soundings taken at intersections
Ranges are paralel to track
Range 1
←To McGehee
Inst. here
1956
1950
1941
1930